Two-way ANOVA Model

1. Data Structure
   1) Response y
   2) Two X variables: X1 is the row variable and has r levels, X2 is the column variable and has c levels
   3) In total, there are r×c cells(groups)
   4) In each cell(group), there are n observations.
   5) Example

		gender	
		Female	Male
		0.51	0.54
	no-sugar	0.63	0.75
treatment		0.45	0.64
		0.65	0.76
	sugar	0.76	0.72
		0.71	0.65

Create the Data set using Excel: for each observation, create a record(a row)

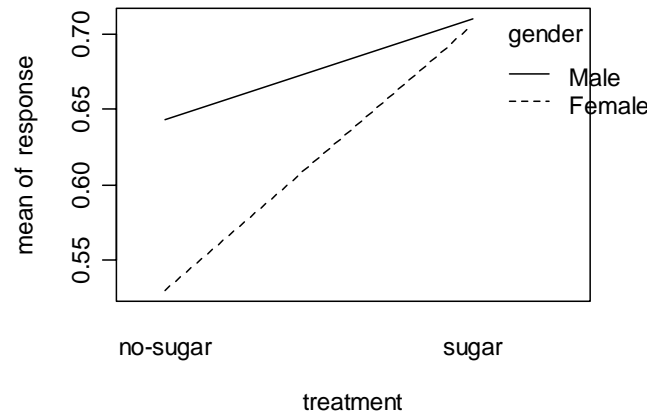| response	treatment	gender
0.51	no-sugar	Female
0.63	no-sugar	Female
0.45	no-sugar	Female
0.65	sugar	Female
0.76	sugar	Female
0.71	sugar	Female
0.54	no-sugar	Male
0.75	no-sugar	Male
0.64	no-sugar	Male
0.76	sugar	Male
0.72	sugar	Male
0.65	sugar	Male

2. Questions of interest
   1) Main effect of X1:
      Ho: There is no difference between means of response of Female and Male rats.
   2) Main effect of X2
      Ho: There is no difference between means of response of sugar and no-sugar diet.
   3) Interaction effect of X1 and X2 on response y
      Ho: There is no interaction between variable X1 and variable X2.

```
treatment<-rat$treatment
gender<-rat$gender
response<-rat$response
interaction.plot(treatment,gender,response)
```


3. ANOVA Table for Testing the Effects of interest
   1) ANOVA model with interaction
      ```
      rat1<-aov(response~treatment*gender,data=rat)
      anova(rat1)
      ```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
treatment	1	0.044408	0.044408	6.9478	0.02990 *
gender	1	0.010208	0.010208	1.5971	0.24189
treatment:gender	1	0.009075	0.009075	1.4198	0.26758
Residuals	8	0.051133	0.006392		

   Conclusion: There is no significant interaction between
               gender and treatment.

   2) ANOVA model without interaction
      Note: Can not test the interaction effect when n=1
      ```
      rat2<-aov(response~treatment+gender,data=rat)
      anova(rat2)
      ```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
treatment	1	0.044408	0.044408	6.6382	0.02987 *
gender	1	0.010208	0.010208	1.5260	0.24799
Residuals	9	0.060208	0.006690		

   Conclusion: Treatment has significant effect on weight gain
   of rats. Rats fed with sugar diet and that fed without
   sugar diet have different weight gain. Gender does no have
   significant effect